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Specification

[Title of the Invention] METHOD FOR MEASURING MIGRATION TIME AND ELECTROPHORESIS DISPLAY DEVICE

[Claims]

[Claim 1] A method for measuring a proper application time in an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment, the proper application time being defined as a time elapsing from the beginning of application of a predetermined drive voltage by a drive voltage source until the pigment in the dispersion liquid has reached the electrode to complete migration, the method comprising:

a step of detecting luminance of the electrophoresis display device with a sensor, and

deriving a respective time elapsing from the application of a predetermined drive voltage by the drive voltage source to the pair of electrodes of the electrophoresis dis-

play device until the luminance value from the sensor substantially reaches saturation, the predetermined drive voltage differing in each instance; and

a step of obtaining a relationship between the drive voltage and a time over which the luminance value from the sensor substantially reaches a saturation value, and deriving a proper application time of the electrophoresis display device for the predetermined drive voltage based on the relationship.

[claim 2] In an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment, a method for measuring a proper application time defined as a time elapsing from the beginning of application of a predetermined drive voltage by a drive voltage source until the pigment in the dispersion liquid has reached the electrode to complete migration, the method comprising:

a step of detecting a current value flowing through the electrophoresis display device during application of a drive voltage,

and deriving a respective time elapsing from the application of a predetermined drive voltage by the drive voltage source to the pair of electrodes of the electrophoresis display device until the detected current value substantially reaches saturation, the predetermined drive voltage differing in each instance; and

a step of obtaining a relationship between the drive voltage and a time over which the detected current value substantially reaches a saturation value, and deriving a

proper application time of the electrophoresis display device for the predetermined drive voltage based on the relationship.

[Claim 3] An electrophoresis display apparatus comprising:

an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment;

a drive voltage source for applying a voltage to the pair of electrodes of the electrophoresis display device so as to drive the electrophoresis display device; and

a voltage application time control apparatus for setting a drive voltage application time by the drive voltage source to the electrophoresis display device, based on a saturation time data value obtained by previously measuring a time elapsing from the beginning of application of a voltage by the drive voltage source until the luminance of the electrophoresis display device has substantially reached saturation.

[Claim 4] An electrophoresis display apparatus comprising:

an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment;

a drive voltage source for applying a voltage to the pair of electrodes of the electrophoresis display device so as to drive the electrophoresis display device;

a sensor for detecting luminance of the electrophoresis display device; and

a voltage application control means for terminating the drive voltage application by the drive voltage source to the electrophoresis display device when an output from the sensor has reached a previously measured output value of the sensor obtained when the luminance of the electrophoresis display device has substantially reached saturation.

[Claim 5] An electrophoresis display apparatus comprising:

an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment;

a drive voltage source for applying a voltage to the pair of electrodes of the electrophoresis display device so as to drive the electrophoresis display device;

a current detection means for detecting a current value through the electrophoresis display device; and

a voltage application control means for terminating the drive voltage application by the drive voltage source to the electrophoresis display device when an output from the current detection means has reached a previously measured output value of the current detection means obtained when the current flowing through the electrophoresis display device has substantially reached saturation.

[Detailed Description of the Invention]

Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

[0001]

[Field of the Invention]

The present invention relates to an electrophoresis apparatus which utilizes the movement of charged pigment within a medium responsive to an applied voltage, and a method for measuring the migration time.

[0002]

[Prior Art]

An electrophoresis display device as shown in Figure **13** is conventionally known. The electrophoresis display device includes two substrates **10** (e.g., glass), at least one of which is light-transitive, the two substrates **10** opposing each other via partitions **11** with a predetermined interspace in between, such that the glass substrates **10** and the partitions **11** constitute an enclosed space. A pair of plane-like transparent electrodes **12** (e.g., ITO) are fixed on the respective inner opposing faces of the glass substrates **10**. An electrophoresis display dispersion liquid **13** is accommodated in the enclosed space. The electrophoresis display dispersion liquid **13** includes a colored dispersion medium **13a** which is colored in e.g., black, and a charged pigment **13b** (e.g., white) which is dispersed within the dispersion medium **13a**.

[0003]

In accordance with such an electrophoresis display device, when a positive voltage and a negative voltage are applied to the upper one of the pair of electrodes **12**, respectively, as shown in Figure **14(A)**, the negatively-charged white pigment **13b** which is dispersed within the colored dispersion medium **13a** is electrophoresed toward an anode so that the white pigment **13b** attaches to the upper anode. By observing the electrophoresis display apparatus in this

state from an eye position as indicated in Figure **14(A)**, the portion in which the white pigment **13b** has attached to form a layer will appear white through the transparent electrode **12** and the glass substrate **10**. On the other hand, by reversing the polarities of the applied voltages, as shown in Figure **14(B)**, the white pigment **13b** will attach to the electrode **12** on the opposite surface to form a layer there. As a result, when observed as indicated in the figure, the electrophoresis display panel will appear black because the white pigment layer **13b** is obscured behind the black dispersion medium **13a**. Since the white pigment layer **13b** attached onto the electrode **12** will remain attached after suspending voltage application, there is no particular need, once the white pigment layer **13b** has attached to the electrode **12**, to apply a voltage other than applying a voltage for retaining the attached state.

[0004]

In an electrophoresis display apparatus which functions under the above principles, it is necessary to continue the application of the drive voltage during the movement of the white pigment **13b**. If the application time is too short, the white pigment **13b** does not reach the electrode **12**, thereby resulting in a decrease of the display contrast. Therefore, it has been common practice in the prior art to set the application time to be longer than necessary by a wide margin.

[0005]

[Problems to be Solved by the Invention]

However, employing too long an application time may result in electrode reactions, electrolysis of the dispersion liquid, etc., thereby leading to a reduced lifetime of the electrophoresis display apparatus. On the other hand,

electrophoresis display apparatuses may use different applied voltages and application times depending on the dispersion medium in the electrophoresis display device, the distance between the electrodes, etc., so that it has been difficult to derive a proper applied voltage and a proper application time for a given electrophoresis display device.

[0006]

Moreover, electrophoresis display apparatuses also suffer from the problems of temporal fluctuation of the proper voltage and/or application time because they are susceptible to some unstable parameters, such as alteration of the dispersion liquid or alteration of the additives (e.g., surfactants) in the dispersion liquid; these are intrinsic to apparatuses for applying a voltage to a liquid. Therefore, there is a need for an electrophoresis display apparatus having a properly adjusted voltage application time and a long lifetime.

[0007]

[Means for Solving the Problems]

In order to attain the above objectives, the present invention provides a method for measuring a proper application time in an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment, the proper application time being defined as a time elapsing from the beginning of application of a predetermined drive voltage by a drive voltage source until the pigment in the dispersion liquid has reached the electrode to complete migration, the method comprising: a step of detect-

ing luminance of the electrophoresis display device with a sensor, and deriving a respective time elapsing from the application of a predetermined drive voltage by the drive voltage source to the pair of electrodes of the electrophoresis display device until the luminance value from the sensor substantially reaches saturation, the predetermined drive voltage differing in each instance; and a step of obtaining a relationship between the drive voltage and a time over which the luminance value from the sensor substantially reaches a saturation value, and deriving a proper application time of the electrophoresis display device for the predetermined drive voltage based on the relationship.

[0009] Alternatively, the present invention provides, in an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment, a method for measuring a proper application time defined as a time elapsing from the beginning of application of a predetermined drive voltage by a drive voltage source until the pigment in the dispersion liquid has reached the electrode to complete migration, the method comprising: a step of detecting a current value flowing through the electrophoresis display device during application of a drive voltage, and deriving a respective time elapsing from the application of a predetermined drive voltage by the drive voltage source to the pair of electrodes of the electrophoresis display device until the detected current value substantially reaches saturation, the predetermined drive voltage differing in each instance; and a step of obtaining a relationship between the drive voltage and a time over which the detected current

value substantially reaches a saturation value, and deriving a proper application time of the electrophoresis display device for the predetermined drive voltage based on the relationship.

[00010] Alternatively, an electrophoresis display apparatus according to the present invention comprises: an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment; a drive voltage source for applying a voltage to the pair of electrodes of the electrophoresis display device so as to drive the electrophoresis display device; and a voltage application time control apparatus for setting a drive voltage application time by the drive voltage source to the electrophoresis display device, based on a saturation time data value obtained by previously measuring a time elapsing from the beginning of application of a voltage by the drive voltage source until the luminance of the electrophoresis display device has substantially reached saturation.

[0011] Alternatively, an electrophoresis display apparatus according to the present invention comprises: an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment; a drive voltage source for applying a voltage to the pair of electrodes of the electrophoresis display device so as to drive the elec-

trophoresis display device; a sensor for detecting luminance of the electrophoresis display device; and a voltage application control means for terminating the drive voltage application by the drive voltage source to the electrophoresis display device when an output from the sensor has reached a previously measured output value of the sensor obtained when the luminance of the electrophoresis display device has substantially reached saturation.

[0012] Alternatively, an electrophoresis display apparatus according to the present invention comprises: an electrophoresis display device comprising an electrophoresis display dispersion liquid accommodated within an enclosed space defined by peripheries including one or more pairs of opposing electrodes, at least one of which is transparent, the electrophoresis display dispersion liquid containing a liquid phase dispersion medium and pigment; a drive voltage source for applying a voltage to the pair of electrodes of the electrophoresis display device so as to drive the electrophoresis display device; a current detection means for detecting a current value through the electrophoresis display device; and a voltage application control means for terminating the drive voltage application by the drive voltage source to the electrophoresis display device when an output from the current detection means has reached a previously measured output value of the current detection means obtained when the current flowing through the electrophoresis display device has substantially reached saturation.

[0013]

[Function]

According to the method for measuring migration time of the present invention, which pays attention to the change in the luminance or current value of an electrophoresis dis-

play device with respect to voltage application time and defines the moment at which the pigment within a dispersion liquid has reached an electrode to substantially completely finish migration as the point of time at which the luminance or current value has substantially reached saturation, an application time is measured from the beginning of the application of a predetermined voltage to the electrophoresis display device until the luminance or current value has substantially reached a saturation value.

[0014]

In accordance with an electrophoresis display apparatus of the present invention, a proper application time corresponding to a drive voltage is set based on the above method, and a voltage application time control apparatus is employed to terminate the voltage application from a drive voltage source after the lapse of the proper application time. By providing such a voltage application time control apparatus in the electrophoresis display apparatus, it becomes possible to obtain a properly minimized application time and minimize deterioration due to electrode reactions or electrolysis without lowering contrast. Moreover, a sensor capable of detecting the luminance of an electrophoresis display device or a current detection means for detecting a current value is provided, and a voltage application control means is employed to terminate the drive voltage application when the output from the sensor or the current detection means has reached an output of the sensor or the current detection means which corresponds to a previously measured saturation value of luminance or current value.

[0015]

[Examples]

Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

Hereinafter, examples of the present invention will be described in detail, although the present invention is not limited to these examples.

[0016]

[Example 1]

Figure 1 is a block diagram of an apparatus used for the method for measuring migration time according to the present invention. The present apparatus includes an electrophoresis display device **2**.

[0017]

The electrophoresis display device **2** includes two substrates **10** (e.g., glass), at least one of which is light-transitive, the two substrates **10** opposing each other via partitions **11** with a predetermined interspace in between, and a pair of plane-like transparent electrodes **12** fixed on the respective inner opposing faces of the glass substrates **10**, such that the glass substrates **10**, the electrodes **12**, and the partitions **11** constitute an enclosed space. In some applications, the electrodes **12** may themselves constitute substrates, in which case the glass substrates **10** can be omitted. It is applicable to provide a number of such enclosed spaces and combine the respective enclosed spaces. Examples of the transparent electrodes **12**, include a desired pattern of indium tin oxide (ITO). The thickness (inter-electrode distance) of the partitions **11** is usually on the order of 20 μm to 1 mm.

[0018]

An electrophoresis display dispersion liquid **13** is accommodated in the enclosed space. The electrophoresis display dispersion liquid **13** includes a colored dispersion

medium 13a and a charged pigment 13b which is dispersed within the dispersion medium.

[0019]

A predetermined voltage is applied to the electrodes 12 of the electrophoresis display device 2 by a drive voltage source 3. A luminance meter (sensor) 21 is disposed in front of the electrophoresis display device 2. As the luminance meter 21, a photosensor such as a photomultiplier can be used. The electrophoresis display device 2 is driven by the drive voltage source 3 with a predetermined voltage. The change in the display (luminance) of the electrophoresis display device 2 is measured by the luminance meter 21, and the data is processed by a processing means 22. Similar measurements are taken by varying the applied voltage from the drive voltage source 3. Following this procedure, the proper application time for various voltages can be derived.

[0020]

Figure 2 shows an exemplary change in the luminance against the voltage application time. It can be seen from Figure 2 that the time over which the pigment completes migration can be detected in the form of saturated luminance; this time is defined as a saturation time data value. In the example shown in Figure 2, the saturation time data value of the electrophoresis display device 2 is 60 millisecond (ms). Therefore, under the applied voltage, any decrease in contrast can be prevented and the deterioration can be minimized by setting the application time at 60 ms. Herein, luminance is defined as a measurement of light amount concerning an areal light source; specifically, luminance is a value obtained by dividing light beams traveling in a given direction from a single point on the plane of an areal light source by a product of the orthogonal pro-

jected area in a given direction of a minute area containing that point and a minute solid angle along that direction.

[0021]

A method for automatically measuring the aforementioned change in luminance against various applied voltages will be described with reference to Figures 3 and 4. Figure 3 illustrates the extent of a range which is stored in the form of a table in the processing means 22 of the measurement apparatus, with respect to a prescribed minimum application time T_L and a prescribed maximum application time T_U as well as a prescribed minimum applied voltage V_L and a prescribed maximum applied voltage V_U.

[0022]

The procedure of the process performed by the processing means 22 will be described with reference to a flowchart of Figure 4. First, the applied voltage V is set at the minimum applied voltage V_L at step S1, and the application time T is set at the minimum application time T_L at step S2. Next, the device (the electrophoresis display device) is driven at the set applied voltage V for the set application time T at step S3. The luminance of the electrophoresis display device 2 is detected by the sensor 21 at step S4, and the luminance, the applied voltage V, and the application time T are stored at step S5. Then, it is determined whether or not the application time has exceeded the maximum application time T_U at step S6. If it has not (N), a predetermined time (ΔT) is added to the application time, and the electrophoresis display device 2 continues to be driven at the applied voltage V for that application time ($T + \Delta T$), thereby measuring the luminance at the set applied voltage V up to the maximum application time T_U. If the application time has exceeded the maximum application

time T_U, it is determined at the next step S8 whether or not the applied voltage has exceeded the maximum applied voltage V_U. If it has not (N), a predetermined voltage (ΔV) is added to the applied voltage, and the process returns to step S2 to drive the electrophoresis display device at that applied voltage ($V + \Delta V$) for the minimum application time T_L, thereby measuring the application time and the luminance at that applied voltage ($V + \Delta V$). By following this procedure of repeatedly incrementally increasing the voltage up to the maximum applied voltage V_U and using it for driving, a relationship between the changes in luminance and the application time can be obtained at intervals of ΔV between the minimum applied voltage V_L and the maximum applied voltage V_U. If the application time has exceeded the maximum applied voltage V_U, the measurement has come to an end, so that the results are displayed in print at the next step S10, and the optimum applied voltage and the optimum application time are determined based on these results at step S11.

[0023]

By using the above-described method for measuring migration time, the proper application time for each individual electrophoresis display device can be easily and securely derived independently of any variation in manufacture, temporal deterioration or the like. By driving the electrophoresis display device for the derived proper application time, deterioration due to electrode reactions or electrolysis can be minimized without lowering contrast.

[0024]

[Example 2]

Figure 5 is a schematic diagram illustrating an example of the electrophoresis display apparatus of the present

invention. The electrophoresis display apparatus includes an electrophoresis display device **2**, a drive voltage source 3a for driving the electrophoresis display device **2**, and an application time control apparatus **4**. Since the electrophoresis display device **2** has already been described, it will be denoted by the same reference numerals, and the description thereof will be omitted.

[0025]

The voltage application time control apparatus **4**, forming a feature of the present example, functions to control the application time of the drive voltage source 3a for the electrophoresis display device **2**. The voltage application time control apparatus **4** can be implemented as e.g., a pulse width setting mechanism incorporating a variable resistor, but the present example is not limited thereto. According to the present invention, a pulse width is previously set. The method for setting such a pulse width can be obtained based on the method for measuring migration time as described in Example 1. For example, in the example illustrated in Figure **2**, the saturation time data value is 60 ms. Accordingly, the application time (pulse width) of the drive voltage by the pulse width setting mechanism is set at 60 ms. Alternatively, it is also applicable to establish a criterion based on the luminance having reached 95% of the saturation value. The setting criterion may also be varied otherwise.

[0026]

According to the present example, it is possible to terminate the voltage application when the pigment in the electrophoresis display device **2** has completed migration. As a result, deterioration due to electrode reactions or electrolysis can be minimized without lowering contrast.

Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

[0027]

[Example 3]

Figure **6** is a block diagram illustrating the structure of an electrophoresis display apparatus according to Example 3 of the present invention. In accordance with this electrophoresis display apparatus, a drive voltage from a drive voltage source **3a** is applied to an electrophoresis display device **2** via a switching section **23** for driving the electrophoresis display device **2**. There is also provided a sensor **21** capable of detecting the luminance of the electrophoresis display device **2**. A signal from the sensor **21** is output to a sensor output determination means **22a**. A voltage application control means is constituted by the sensor output determination means **22a** and the switching section **23**.

[0028]

The procedure of processing by the sensor output determination means **22a** will be described with reference to the flowchart of Figure **7**. A saturation sensor output value **THL** corresponding to a saturation luminance (e.g., the luminance at 60 ms in Figure 2) is previously derived and set. The saturation sensor output value **THL** and the sensor output **L** are compared against each other so that a signal for terminating the voltage application is output to the switching section **23** when the sensor output **L** exceeds the sensor output determination means **22a**. Receiving this signal, the switching section **23** terminates voltage application from the drive voltage source **3a**.

[0029]

As a result, it is possible to terminate the driving of the electrophoresis display device when the pigment has completed its movement. As a result, deterioration due to

electrode reactions or electrolysis can be securely prevented.

[0030]

Alternatively, it is also possible to construct the electrophoresis display, whose luminance is to be detected by means of a sensor, as a separate element from a panel for performing the actual display function as a monitor, and may be internalized. The same sensor and the like as those in Example 1 can be used. In an internalized configuration, low-sensitivity sensors can also be used since the light of high intensity can be employed for detection.

[0031]

[Example 4]

Figure **8** is a block diagram illustrating another apparatus used for measuring migration time according to the present invention. The method according to Example 4 differs from the method employing the apparatus shown in Figure **1** on the following points: The method employing the apparatus shown in Figure **1** is a method for deriving the proper application time for various voltages by measuring the change in the display (luminance) of the electrophoresis display device **2** by means of the luminance meter **21**, processing the data in the processing means **22**; and taking similar measurements while varying the applied voltage from the drive voltage source **3**. Following this procedure, the proper application time for various voltages can be derived. On the other hand, the method according to Example 4 is a method for deriving the proper application time for various voltages by measuring the value of the current flowing through the electrophoresis display device **2** during the application of a drive voltage by e.g., a current detector **24** equipped with a monitor, processing the data values in a

processing means **25**, and taking similar measurements while varying the applied voltage from the drive voltage source **3**.

[0032]

The present method is based on the fact that the value of the current flowing during the application of the drive voltage changes depending on whether the particles (pigment **13b**) are in the process of moving (migrating) or they have reached the surface of an electrode **12**. Specifically, the current becomes large while the charged pigment is migrating, and becomes small when the charged pigment has reached the electrode surface. Based on this principle, the present method makes it possible to minimize the application time of the drive voltage by detecting the moment at which the pigment has thoroughly moved to the other electrode based on measurement of the current during the application of the drive voltage.

[0033]

An exemplary change in the current flowing through the electrophoresis display device **2** over voltage application time is shown in Figure **9**. The present example illustrates an exemplary current data obtained by applying the drive voltage for 400 milliseconds (ms). It can be seen from Figure **9** that the time over which the pigment completes migration can be detected in the form of current saturation; this time is defined as a saturation time data value. In the example shown in Figure **9**, the saturation time data value of the electrophoresis display device **2** is 300 ms. Therefore, under the applied voltage, any decrease in contrast can be prevented and the deterioration can be minimized by setting the application time at 300 ms.

[0034]

Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

A method for automatically measuring the aforementioned change in luminance against various applied voltages will be described with reference to Figure 3 (which we referred to in the description of the foregoing example) and Figure 10. As mentioned above, Figure 3 illustrates the extent of a range which is stored in the form of a table in the processing means 25 of the measurement apparatus, with respect to a prescribed minimum application time T_L and a prescribed maximum application time T_U as well as a prescribed minimum applied voltage V_L and a prescribed maximum applied voltage V_U.

[0035]

The procedure of the process performed by the processing means 25 will be described with reference to a flowchart of Figure 10. First, the applied voltage V is set at the minimum applied voltage V_L at step ST1, and the application time T is set at the minimum application time T_L at step ST2. Next, the device (the electrophoresis display device) is driven at the set applied voltage V for the set application time T at step ST3. The current flowing through the electrophoresis display device 2 is detected by the current detector 24 at step ST4, and the detected current value, the applied voltage V, and the application time T are stored at step ST5. Then, it is determined whether or not the application time has exceeded the maximum application time T_U at step ST6. If it has not (N), a predetermined time (ΔT) is added to the application time, and the electrophoresis display device 2 continues to be driven at the applied voltage V for that application time ($T + \Delta T$), thereby measuring the current value at the set applied voltage V up to the maximum application time T_U. If the application time has exceeded the maximum application time T_U, it is determined at the next step ST8 whether or not the applied voltage has

exceeded the maximum applied voltage V_U. If it has not (N), a predetermined voltage (ΔV) is added to the applied voltage, and the process returns to step ST2 to drive the electrophoresis display device 2 at that applied voltage ($V + \Delta V$) for the minimum application time T_L, thereby measuring the application time and the luminance at that applied voltage ($V + \Delta V$). By following this procedure of repeatedly incrementally increasing the voltage up to the maximum applied voltage V_U and using it for driving, a relationship between the changes in luminance and the application time can be obtained at intervals of ΔV between the minimum applied voltage V_L and the maximum applied voltage V_U. If the application time has exceeded the maximum applied voltage V_U, the measurement has come to an end, so that the results are displayed in print at the next step ST10, and the optimum applied voltage and the optimum application time are determined based on these results at step ST11.

[0036]

As described above, by using the method for measuring migration time according to Example 4, as in the above-described method for measuring migration time according to Example 1, the proper application time for each individual electrophoresis display device can be easily and securely derived independently of any variation in manufacture, temporal deterioration or the like. By driving the electrophoresis display device for the derived proper application time, deterioration due to electrode reactions or electrolysis can be minimized without lowering contrast.

[0037]

[Example 5]

Figure 11 is a schematic diagram illustrating an electrophoresis display apparatus according to Example 5 of

the present invention. The electrophoresis display apparatus includes an electrophoresis display device **2**, a drive voltage source **3a** for driving the electrophoresis display device **2**, and an application time control apparatus **4a** for controlling the voltage application time of the drive voltage source **3a** for the electrophoresis display device **2**. Since the electrophoresis display device **2** has already been described, it will be denoted by the same reference numerals, and the description thereof will be omitted.

[0038]

The voltage application time control apparatus **4a**, forming a feature of the present example, functions to control the application time of the drive voltage source **3a** for the electrophoresis display device **2**. The voltage application time control apparatus **4a** can be implemented as e.g., a pulse width setting mechanism incorporating a variable resistor, but the present example is not limited thereto. According to Example 5, as in the above-described Example 2, a driving pulse width is previously set. The method for setting the pulse width by the voltage application time control apparatus **4a** can be obtained based on the method for measuring migration time as described in Example 4. For example, in the example illustrated in Figure **9**, the saturation time data value is 300 ms. Accordingly, the application time (pulse width) of the drive voltage by the pulse width setting mechanism is set at 300 ms. Alternatively, in this case, too, it is also applicable to establish a criterion based on the luminance having reached 95% of the saturation value. The setting criterion may also be varied otherwise.

[0039]

According to Example 5, as in the above-described Example 2, it is possible to terminate the voltage application

when the pigment in the electrophoresis display device 2 has completed migration. As a result, deterioration due to electrode reactions or electrolysis can be minimized without lowering contrast.

[0040]

[Example 6]

Figure **12** is a schematic diagram illustrating the structure of an electrophoresis display apparatus according to Example 6 of the present invention. The electrophoresis display apparatus includes an electrophoresis display device 2, a drive voltage source **3a** for driving the electrophoresis display device 2, a pulse control circuit 5 for receiving the supply voltage from the drive voltage source **3a** and generating a drive pulse signal **S5** to be applied to the electrophoresis display device 2, the drive pulse signal **S5** having a predetermined width, a current meter **24a** for detecting the value of a current flowing through the electrophoresis display device 2 during the application of the drive voltage, and a current saturation detection circuit **25a** for outputting a control signal **S25** to the pulse control circuit 5 for terminating the pulse output from the pulse control circuit 5 when a saturation state, as indicated by the current value measured by the current meter **24a** reaching e.g., approximately 200 μA (*note to the inventor: please confirm the value and unit of the current [sic]), has been reached. A voltage application control means is constituted by the pulse control circuit 5 and the current saturation detection circuit 25.

[0041]

According to Example 6, as in the above-described Example 3, it is possible to securely terminate the driving of the electrophoresis display device 2 when the pigment has

completed movement. As a result, deterioration of the electrophoresis display device due to electrode reactions or electrolysis can be securely prevented.

[0042]

[Effects of the Invention]

According to the method for measuring migration time of the present invention, a proper voltage and a proper application time for an electrophoresis display apparatus can be easily derived.

[0043]

Based on luminance detection, various embodiments are possible: only a portion of a display surface may be spot-measured or the entire display surface may be equally measured. Based on current detection, fine control is possible because analog values are directly measured.

[0044]

In accordance with the electrophoresis display apparatus of the present invention, it is ensured that a voltage is applied for a proper time. As a result, deterioration due to electrode reactions or electrolysis can be minimized without lowering contrast. Moreover, since an electrophoresis display apparatus according to the present invention detects a proper time to terminate voltage application, deterioration due to electrode reactions or electrolysis can be securely prevented without lowering contrast.

[0045]

Based on luminance detection, the luminance at a point when the luminance has undergone a thorough change, that is, when the display has thoroughly changed, is detected. As a result, a highly-reliable proper applied volt-

age and a highly-reliable proper application time can be easily derived. Based on current detection, there is an advantage in that no extraneous equipment such as a luminance meter is required, thereby leading to simple circuitry, and it is easy to construct a so-called feedback loop, and so on.

[Brief Description of the Drawings]

[Figure 1]

Figure 1 is a schematic diagram illustrating an apparatus for use in the method for measuring migration time according to the present invention.

[Figure 2]

Figure 2 is a graph illustrating the change in luminance over voltage application time of the electrophoresis display apparatus.

[Figure 3]

Figure 3 is a graph illustrating a prescribed range of application time and applied voltage.

[Figure 4]

Figure 4 is a flowchart illustrating an exemplary processing procedure in the method for measuring migration time according to the present invention.

[Figure 5]

Figure 5 is a schematic diagram illustrating the structure of the electrophoresis display apparatus according to Example 2 of the present invention.

[Figure 6]

Figure **6** is a block diagram illustrating the structure of the electrophoresis display apparatus according to Example 3 of the present invention.

[Figure **7**]

Figure **7** is a flowchart illustrating an exemplary processing procedure of a sensor output determination means.

[Figure **8**]

Figure **8** is a schematic diagram illustrating an apparatus used for another method for measuring migration time according to the present invention.

[Figure **9**]

Figure **9** is a graph illustrating change in a current against voltage application time in the electrophoresis display apparatus.

[Figure **10**]

Figure **10** is a flowchart illustrating another processing procedure in the method for measuring migration time according to the present invention.

[Figure **11**]

Figure **11** is a block diagram illustrating the structure of the electrophoresis display apparatus according to Example 5 of the present invention.

[Figure **12**]

Figure **12** is a block diagram illustrating the structure of the electrophoresis display apparatus according to Example 6 of the present invention.

[Figure **13**]

Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

Figure 13 is a block diagram illustrating the structure of an electrophoresis display device.

[Figure 14]

Figure 14 is a illustrative diagram illustrating the operation of an electrophoresis display device.

[Description of the Reference Numerals]

2	electrophoresis display device
3, 3a, 3b	drive voltage source
4, 4a	voltage application time control apparatus
5	pulse control circuit
10	glass substrate
11	partition
12	electrode
13	electrophoresis dispersion liquid
13a	electrophoresis dispersion medium
13b	pigment
21	luminance meter (sensor)
22, 25	processing means
24	current detector
24a	current meter
25a	current saturation detection circuit

SHUSAKU YAMAMOTO

Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

[Name of the Document] ABSTRACT

[Abstract]

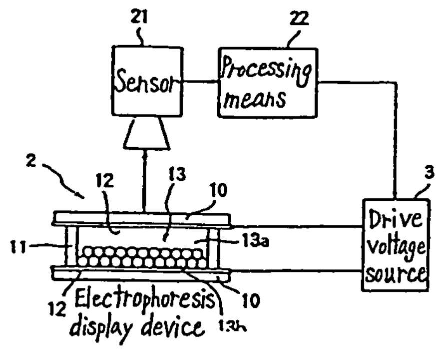
[Objective] An objective of the present invention is to provide a method for measuring migration time which is capable of minimizing deterioration due to electrode reactions or electrolysis without lowering contrast.

[Structure] The time required for pigment **13b** in an electrophoresis display device **2** to move is measured in terms of saturation time of luminance. A voltage application time control apparatus **4**, whose drive voltage application time is set to the luminance saturation time, is provided in the electrophoresis display apparatus. Alternatively, a sensor **21** capable of detecting the luminance of the electrophoresis display device **2** is provided, with a voltage application control means capable of terminating drive voltage application when the output of the sensor **21** has reached a sensor output corresponding to a previously measured saturation value of luminance.

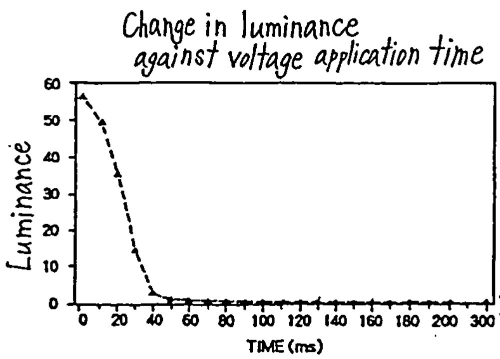
Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

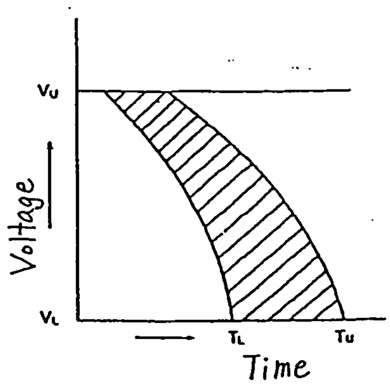
[Fig. 1]



[Fig. 2]



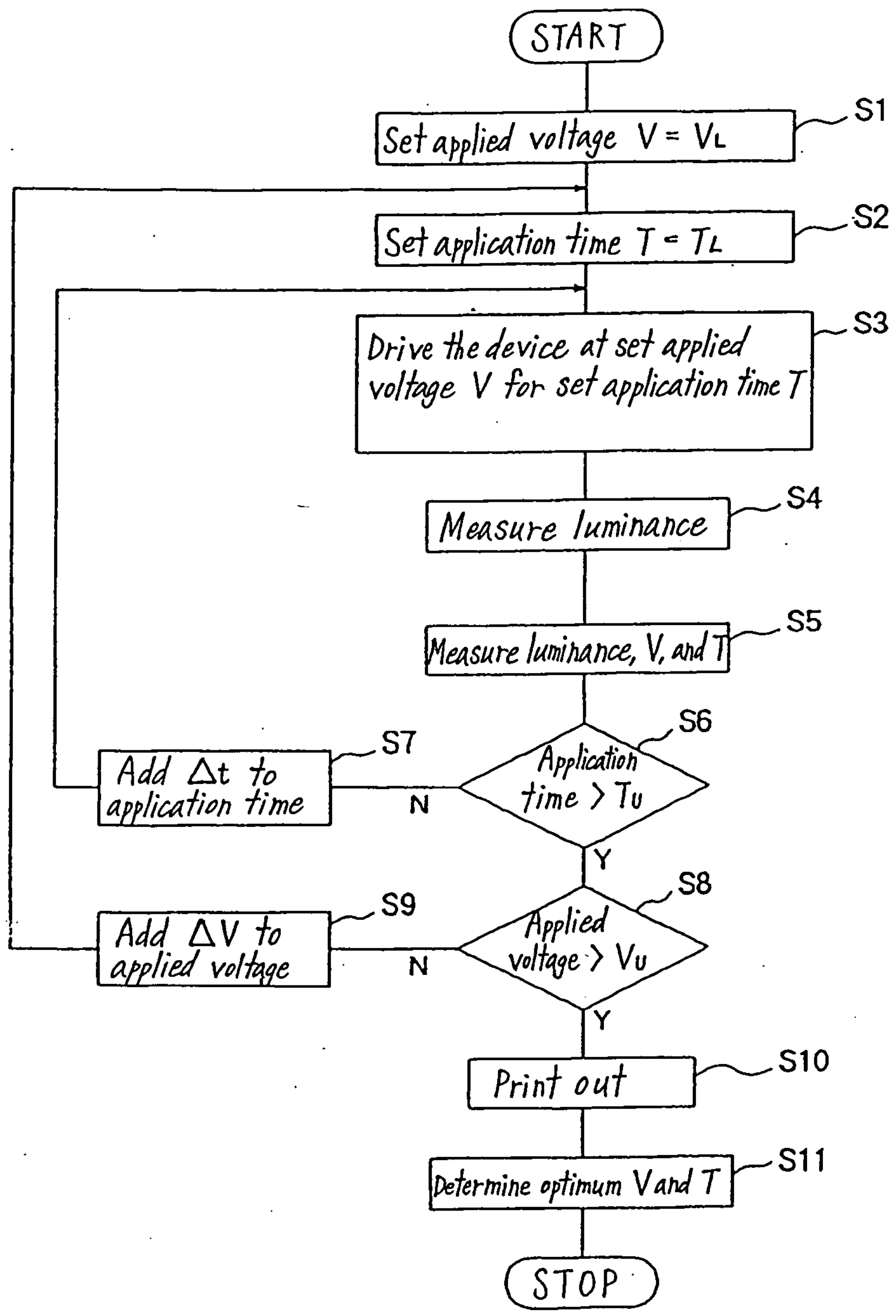
[Fig. 3]



Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

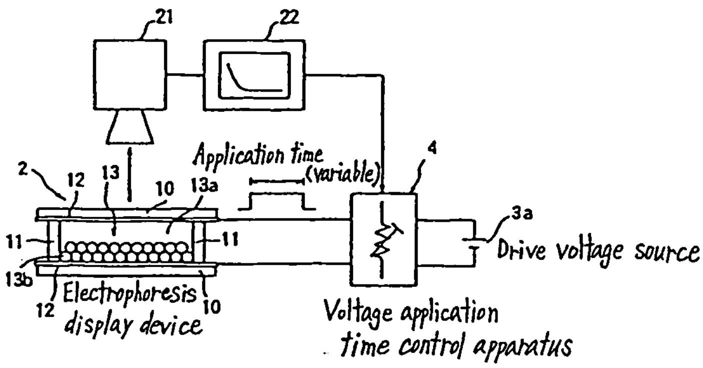
(Fig. 4)



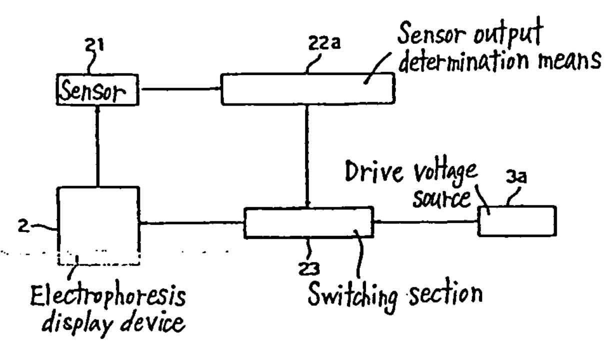
Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

(Fig. 5)



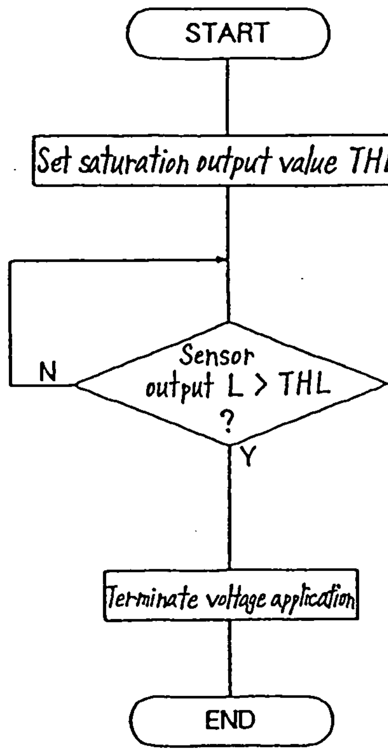
(Fig. 6)



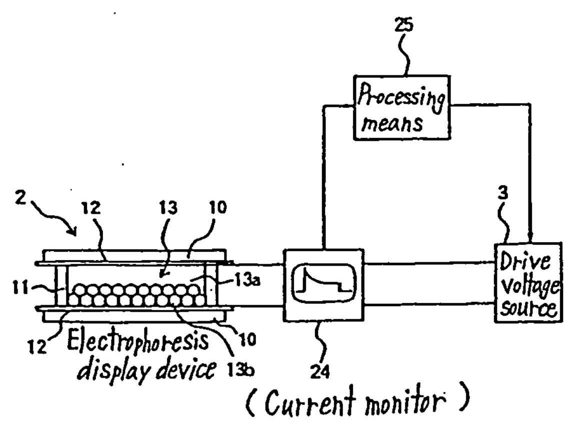
Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

(Fig. 7)



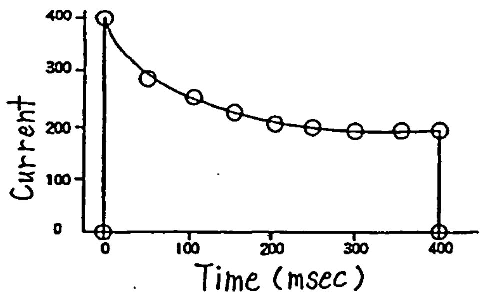
(Fig. 8)



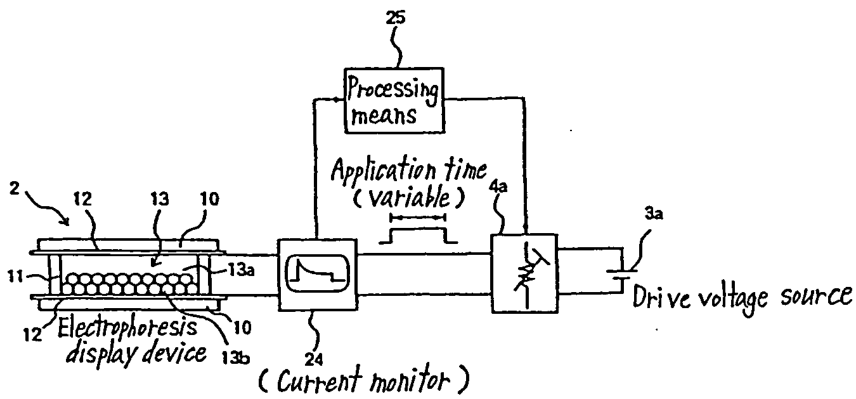
Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

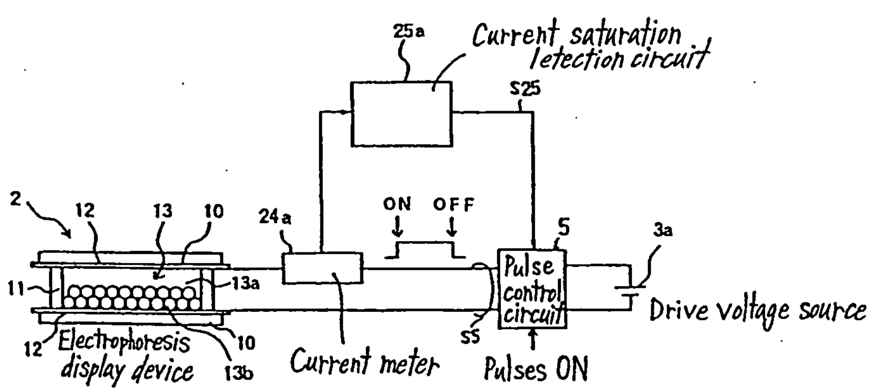
[Fig. 9]



[Fig. 11]



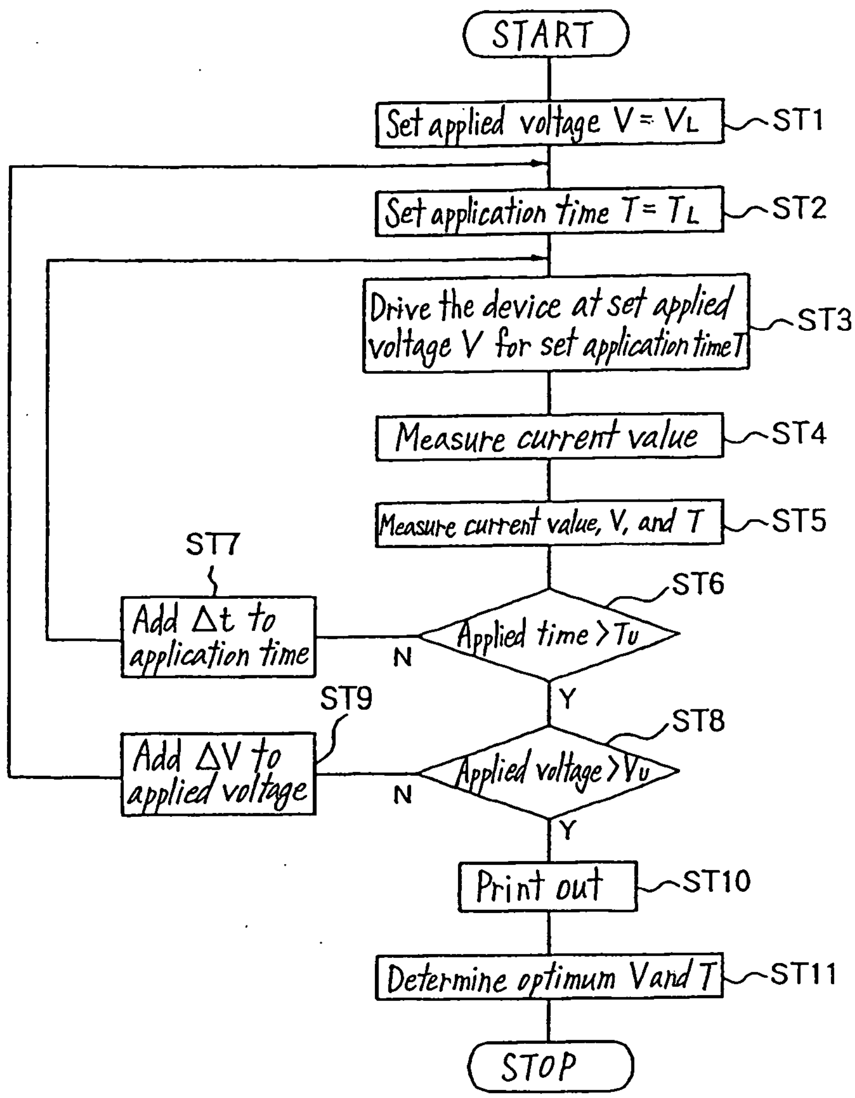
[Fig. 12]



Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

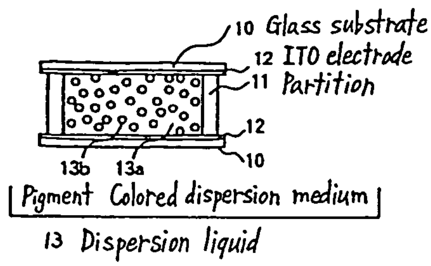
[Fig. 10]



Your Ref: 2108/2

Japanese Laid-Open Publication No. 9-6277

[Fig. 13]



[Fig. 14]